01-03-00

A/Reissue

PATENT

jc583 U.S. PTO
12/29/99

jc525 U.S. PTO
09/474867
12/29/99

ASSISTANT COMMISSIONER FOR PATENTS
WASHINGTON, D.C. 20231

Sir:

Transmitted herewith for filing is the **Reissue Application of U.S. Patent No. 5,853,308**, issued 12/29/98.

Inventor(s): **Masayoshi Nanami, Ryoichi Nakase, and Tetsuya Mashiko**

For: **ENGINE AND EXHAUST SYSTEM FOR WATERCRAFT**

Enclosed are:

(X) A Reissue Application Fee Determination Record in duplicate.

(X) A single-column copy of the specification, claims, and abstract.

(X) Formal duplicates of the printed drawings of the issued patent.

(X) Information Disclosure Statement, Form PTO-1449 with 18 references.

(X) A return prepaid postcard.

(X) A check in the amount of $1,216 to cover the filing fee is enclosed.

(X) The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Account No. 11-1410. A duplicate copy of this sheet is enclosed.

(X) Please use Customer No. 20,995 for the correspondence address.

09474867 122999

William H. Shreve
Registration No. 35,678
Attorney of Record

H:\DOCS\WHS\WHS-2463.DOC
122999

REISSUE APPLICATION FEE DETERMINATION RECORD

CLAIMS AS FILED - PART I					
	CLAIMS IN PATENT	**NUMBER FILED IN REISSUE APPLICATION**	**NUMBER EXTRA**	**RATE**	**FEE**
BASIC FEE					$760
TOTAL CLAIMS	26	47	21	$18	$378
INDEP. CLAIMS	3	4	1	$78	$78
				TOTAL FILING FEE	**$1,216**

(X) A check in the amount of $1,216 to cover the filing fee is enclosed.

(X) The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Account No. 11-1410. A duplicate copy of this sheet is enclosed.

(X) Please use Customer No. 20,995 for the correspondence address.

Will. H. S

William H. Shreve
Registration No. 35,678
Attorney of Record

ENGINE AND EXHAUST SYSTEM FOR WATERCRAFT

This application is a continuation of U.S. patent application Ser. No. 08/318,055, filed Oct. 4, 1994, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to an engine and more particularly to an improved engine and exhaust system for use in a watercraft and particularly a small personal type of watercraft.

Growing in popularity is a relatively small type of watercraft referred to as a "personal watercraft". This type of watercraft is relatively small and is designed primarily to accommodate a rider and no more than one or two passengers. Frequently these watercraft are quite sporting in nature and the operator and passengers may be seated in a straddle tandem fashion. Often times, jet pumps are utilized as the propulsion device for such watercraft.

As with all watercraft, this type of personal watercraft requires the use of a relatively compact power plant. For that reason, it has been proposed to employ two-cycle crankcase compression, internal combustion engines as the power plant. These engines are quite compact. In addition, since the cylinders of the engine fire each revolution of the crankshaft, they have a relatively large power output for their specific displacement.

As with all engines, however, there are certain spatial considerations that still must be considered. For example, if in-line engines are employed, they tend to have not only considerable length for their displacement, but also may have substantial height. V-type engines, on the other hand, offer some reduction in length but the width of the engine becomes greater. In addition, V-type engines present certain problems in conjunction with the location of the induction and exhaust systems. These problems are particularly acute in conjunction with two-cycle crankcase compression engines employing multiple cylinders.

It is, therefore, a principal object of this invention to provide an improved and compact two-cycle V-type engine that can be utilized as the propulsion device in a small watercraft.

It is a further object of this invention to provide an improved compact two-cycle crankcase compression internal combustion engine wherein the induction and exhaust systems are laid out in such a way as to provide a compact arrangement and yet afford accessibility for components which must be serviced.

It is frequently the practice with V-type engines to mount the cylinder banks in a staggered relationship so that the cylinders of the adjacent banks may have their connecting rods journaled on a common throw of a common crankshaft. However, the staggering of the cylinder banks increases the length of the engine.

It is, therefore, a still further object of this invention to provide an improved and compact type of the two-cycle crankcase compression engine.

As has been noted, the personal watercraft are frequently powered by jet pumps commonly known as jet propulsion units. However, it is also well known that the impeller system of a jet propulsion unit can be subject to cavitation if driven at too high a speed. On the other hand, in order to provide a compact propulsion unit, it is desirable to operate the engine at a high rate of speed. By increasing the speed

of the engine it is possible to increase the power of the engine without increasing its size. However, when the engines run at high speed, then the speed of the output shaft of the engine is such that the impeller of the jet propulsion unit may be driven at too high a speed.

It has, therefore, been proposed to provide a transmission between the engine and jet propulsion unit so as to permit the engine to operate at the desired speed without causing cavitation of the impeller. This arrangement, however, adds further to the bulk of the unit and provides problems such as alignment of the various components and so forth.

It is, therefore, a still further object of this invention to provide an improved V-type two-cycle crankcase compression engine for a watercraft that can include a built-in transmission in its construction.

SUMMARY OF THE INVENTION

A first feature of the invention is adapted to be embodied in an inboard, two-cycle, crankcase compression internal combustion engine unit for a watercraft having a crankcase chamber journalling an output shaft. A pair of cylinder blocks extend at a V-angle to each other and are affixed to the crankcase chamber. Each cylinder block contains at least one piston for driving the output shaft. An induction system for the propulsion unit is disposed substantially completely in a valley defined between the cylinder banks. A pair of exhaust manifolds are each affixed to a respective one of the cylinder blocks on a side facing away from the valley.

Another feature of the invention is also adapted to be embodied in an inboard, two-cycle, crankcase compression internal combustion engine unit for a watercraft having a crankcase chamber journalling an output shaft. A pair of cylinder blocks extend at a V-angle to each other and are affixed to the crankcase chamber. Each cylinder block contains at least one piston for driving a respective crankshaft journalled in the crankcase chamber. The crankshafts of the respective cylinder blocks are coupled to each other and to an output shaft by a transmission and the output shaft is adapted to drive a propulsion unit of the watercraft.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side elevational view of a small watercraft powered by a propulsion unit constructed in accordance with a first embodiment of the invention, with a portion broken away and another portion shown in its normal operating condition in solid lines and in respective service positions in phantom lines.

FIG. **2** is a top plane view of the watercraft shown in FIG. **1**.

FIG. **3** is an enlarged rear elevational view of the engine of the watercraft, with portions broken away and shown in sections.

FIG. **4** is a cross-sectional view taken along the line **4**—**4** of FIG. **3** showing the pistons in phantom.

FIG. **5** is a side elevational view, in part similar to FIG. **1**, and shows a watercraft constructed in accordance with another embodiment of the invention.

FIG. **6** is a top plane view of this embodiment.

FIG. **7** is a view, in part similar to FIG. **3**, and shows the engine of this embodiment, with portions broken away and shown in sections.

FIG. **8** is an enlarged side elevational view of the engine, with a portion of the exhaust system broken away and shown in sections.

FIG. 9 is a top plane view of the engine of this embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

Referring first in detail to the embodiment of FIGS. 1–4 and initially primarily to FIGS. 1 and 2, a small personal watercraft constructed in accordance with this embodiment of the invention is identified generally by the reference numeral 11. It is to be understood that, although the invention is described in conjunction with a personal type of watercraft, certain facets of the invention may be utilized with other types of watercraft. Also, the personal watercraft 11 that is illustrated has a form which is particularly useful with the invention. However, watercraft of other forms may also be employed as will be readily apparent to those skilled in the art. In addition, certain features of the layout of the watercraft 11 are particularly useful in that they afford accessibility of the engine and certain of its components, as will become apparent.

The watercraft 11 is comprised of a hull, indicated generally by the reference numeral 12 which is comprised of an under hull portion 13 and a deck portion 14. The hull portion 13 and deck portion 14 may be formed from any suitable material such as a molded fiberglass reinforced resin or the like. The hull and deck portions 13 and 14 are affixed to each other in any known manner, such as by bonding adhesive or welding. A bumper section 15 is affixed to the forward portion of the hull 12 at the area around the joint between the hull portion 13 and deck portion 14.

The rear portion of the deck 14 accommodates a seat 16 which extends longitudinally of the watercraft in a passenger's area. The seat 16 is designed so as to accommodate an operator and one or two passengers seated in straddle tandem fashion. A pair of depressed foot areas are disposed on opposite sides of the seat 16 so as to accommodate the legs of the riders.

Disposed immediately forwardly of the seat 16 is a control mast 17 mounting a handlebar assembly 18 for steering of the watercraft 11 in a manner which will be described. The mast 17 is mounted on a hatch assembly 19 that covers an engine compartment, as will be described. This hatch assembly 19 is mounted by means of a hinge 21 for pivotal movement between a normal operative condition as shown in solid lines in FIGS. 1 and 2 and an opened or access position as shown in phantom lines in FIG. 1. The control mast 17 and handlebar assembly 18 are mounted on the hatch 19 and pivot with it.

In addition, the hatch 19 is provided with a smaller opening having a further pivotally supported cover 22 that is pivoted at its forward end and so as to afford access to the engine compartment for servicing without needing to pivot the entire hatch assembly 19.

As has been noted, the area beneath the hatch 19 forms an engine compartment and an internal combustion engine, constructed in accordance with an embodiment of the invention and indicated generally by the reference numeral 23 in mounted therein in a suitable manner. An example of such a mounting will be described later by reference to the embodiment of FIGS. 5–9. The construction of the engine 23 will be described later by more reference to FIGS. 3 and 4 but in the illustrated embodiment the engine 23 is a V-4 two-cycle crankcase compression engine. The invention has particular utility with such engines.

The engine 23 has an output shaft 24 that drives a drive shaft 25 through which extends rearwardly and is journaled

by a bearing **26** on a bulkhead assembly **27**. The bulkhead assembly **27** is formed at the front end of a tunnel **28** that is formed in the under side of the hull portion **13** and beneath the seat **16**. A flexible joint **30** is interposed in the connection between the output shaft **24** and the drive shaft **25**.

A jet propulsion unit, indicated generally by the reference numeral **29** is mounted within this tunnel **28** in a suitable manner. The jet propulsion unit **29** may be of any known type and is comprised of an outer housing assembly defining a water inlet portion **31** which defines a downwardly facing water inlet opening flush with the bottom surface of the hull portion **13**. An impeller housing **32** is formed at the end of the water inlet portion **31** and contains an impeller **33**. The impeller **33** is affixed to an impeller shaft **34** which may be either connected to or integrally formed with the drive shaft **25** so as to be driven by the engine **23**.

The impeller **33** draws water through the inlet opening portion **31** as shown by the arrows in FIG. **1** and discharges it rearwardly through a discharge nozzle portion **34**. The discharge nozzle portion **35** pivotally supports a steering nozzle **36** which is pivotal about a vertically extending steering axis. This steering nozzle **36** is coupled to the handlebar assembly **18** in a known manner, as by means of a bowden wire cable (not shown) for steering of a watercraft **11** in a well known manner.

If desired, a reverse thrust bucket **37** may be mounted at the discharge end of the steering nozzle **36** for movement between a forward drive position and a reverse drive position as shown in FIG. **1**, where the water from the discharge nozzle **35** will be redirected in a forward direction so as to affect a reverse thrust on the watercraft **11**. The reverse thrust bucket **37** is operated in any known manner.

Except for the hatch assembly **19**, the construction as thus far described may be considered to be conventional and, for that reason, further description of the conventional portions of the watercraft **11** is not believed to be necessary. Where any component is not illustrated or described, it may be considered to be of any conventional type of construction.

The construction of the engine **23** will now be described by primary reference to FIGS. **3** and **4** although certain of the engine components appear in FIGS. **1** and **2**. As has been noted, the engine **23** is of the V-4 type and operates on a two-cycle, crankcase compression principle. The engine **23** is comprised of a crankcase assembly, indicated generally by the reference numeral **38** and which is comprised, in the illustrated embodiment, of a lower portion **39** and an upper portion **41** which are connected to each other in a known manner. The crankcase portions **39** and **41** may be formed from any suitable material such as light weight aluminum or aluminum alloy castings.

A pair of cylinder blocks **42** and **43** are affixed to the opposite sides of the crankcase assembly **38** and are inclined at a V-angle to each other so as to define a valley **44** therebetween. Each cylinder block **42** is formed with a pair of respective cylinder bores **45** and **46**. Pistons **47** and **48** are slidably supported in the cylinder bores **45** and **46**, respectively, and are connected by means of piston pins **49** and **51** to respective connecting rods **52** and **53**. The connecting rods **52** of the left hand cylinder bank **42** are connected at their lower or big ends to the throws of a first crankshaft **54** that is rotatably journaled in the crankcase chamber **38** by means of a plurality of spaced main bearings **55**. The main bearings **55** are of the roller type. It should be noted that the crankshaft **54** is offset transversely relative to the output shaft **24** and disposed vertically above it as clearly seen in FIG. **3**.

In a similar manner, the connecting rods **53** of the cylinder block **43** are connected at their lower or big ends to a second crankshaft **56** that is rotatably journaled about an axis that lies in the same plane as the axis of the first crankshaft **54** but on the opposite side of the output shaft **24**. Roller type main bearings **57** provide the rotational support for the second crankshaft **56** in the crankcase assembly **38**. It should be noted that the roller bearings **55** and **57** are axially aligned with each other as are the throws of the crankshafts **54** and **56**. This is possible due to the use of the two crankshafts **54** and **56** and thus there is no stagger between the cylinder banks **42** and **43**. This per its a lower overall length for the engine than other more conventional type of V-type engines.

The output shaft **24** is journaled on the longitudinal center line of the watercraft **11** between the crankshafts **54** and **56** and below them, as already noted. Roller type bearings **58** are provided in the crankcase assembly **38** for journalling the output shaft **24**.

A pair of gears **59** and **61** are affixed to the rear ends of the crankshafts **54** and **56**, respectively. The gears **59** and **61** have the same diameter. These gears mesh with a timing gear **62** that is affixed to the output shaft **24** so as to establish not only a drive to the output shaft **24** but a timing relationship between the crankshafts **54** and **56** so that they rotate at the same speeds. Also, due to the location of the shafts **54** and **56** they will rotate in the same direction.

In the illustrated embodiment, the ratio between the gears **59** and **61** and the timing gear **62** is one-to-one but, if desired, a gear reduction may be employed so that the output shaft **24** rotates at a slower speed than the crankshafts **54** and **56**. Such an arrangement will permit a higher speed of the engine **23** without cavitation of the impeller **33** of the jet propulsion unit **29**. The timing transmission between the crankshafts **54** and **56** comprised of the gears **59**, **61** and **62** is enclosed by a cover plate **60** that is affixed to the respective end of the crankcase assembly **38**.

Cylinder head assemblies **64** and **65** are affixed to the cylinder blocks **42** and **43**, respectively, and form the combustion chambers for the engine along with the cylinder bores **45** and **46** and pistons **47** and **48**. Spark plugs **66** are mounted in the cylinder heads **65** and are fired by an ignition system which includes a magneto generator assembly **67** which is mounted at the end of the crankcase **38** opposite to the timing gears **59**, **61** and **62**. This flywheel magneto **67** is contained within an extension **68** of the crankcase assembly **38**. As a result of this arrangement, the engine is quite compact.

As is well known in two-cycle crankcase compression engines, the crankcase chamber in which the crankshafts **54** and **56** rotate is divided into a plurality of sections or portions each associated with a respective one of the cylinder bores **45** and **46**. These portions are sealed from each other. This includes crankcase chambers **69** associated with the cylinder block **42** and crankcase chambers **71** associated with the cylinder block **43** and associated with its cylinder bores **46**. An induction system, indicated generally by the reference numeral **72** is provided for delivering a fuel/air charge to the crankcase chamber **69** and **71**. In accordance with a feature of the invention, the induction system **72** is disposed in substantial part in the valley **44** between the cylinder blocks **42** and **43**. This provides a compact assembly and also permits the maintenance of a low overall height for the engine **23**.

The induction system **72** is comprised of a pair of dual down draft carburetors **73** that are mounted on an intake manifold **74**. Air is delivered to the down draft carburetors

73 from respective air inlet and silencer devices 75. Each barrel of each carburetor 73 serves one crankcase chamber 69 or 71 of the respective cylinder block 42 and 43. The intake manifold 74 has individual runners that cooperate with intake ports 76 and 77 divided by a dividing wall 78 of the upper crankcase member 41. Reed type check valves 79 and 81 are positioned in each of the intake ports 76 and 77 for permitting a charge to flow into the respective crankcase chambers 69 and 71 as the pistons 47 and 48 move upwardly and which preclude reverse flow as these pistons move downward.

Upon the downward movement of the pistons 47 and 48, the charge in the individual crankcase chambers 69 and 71 is compressed and then transferred to the combustion chambers above the pistons 47 and 48 through respective scavenge passages (not shown). This type of structure is well known in the art. The charge is then further compressed in each combustion chamber and is fired by the respective spark plug 66 therein in a timed relationship by the ignition system thus far described.

When the charge burns it expands and drives the pistons 47 and 48 downwardly and eventually opens exhaust ports 82 and 83 formed in the cylinder blocks 42 and 43 on the side thereof away from the valley 44. These exhaust gases are then delivered to respective exhaust manifolds 84 and 85 that are affixed to the outer sides of the cylinder blocks 42 and 43, respectively. As may be seen in FIGS. 1 and 2, these exhaust manifolds 84 and 85 extend along the sides of the engine 23 and thus maintain a compact arrangement.

Referring now again primarily to FIGS. 1 and 2, it will be noted that the central placement of the carburetors 73 positions them beneath the hatch cover 19 and accessible through the opening closed by the smaller cover 22. This permits servicing of both the carburetors 73 and also the spark plugs 66 through the smaller hatch cover 22.

The engine 23 is water cooled and water for its cooling is drawn from the body of water in which the watercraft 11 is operated in any well known manner. A suitable engine driven water pump may be provided for this purpose. The water is then circulated through cooling jackets in the cylinder blocks 42 and 43 and cylinder head assemblies 64 and 65. This water is then discharged into a cooling jacket which may encircle the exhaust manifolds 84 and 85 and around respective expansion chambers 86 and 87 that are disposed on opposite sides of the engine 23 and which extend along the cylinder blocks 42 and 43 and extend vertically upwardly above them to a small extent as best seen in FIG. 3. At some point this cooling water is then mixed with the exhaust gases so as to achieve silencing and cooling of the exhaust gases.

Each expansion chamber 86 and 87 communicates through a respective conduit 88 and 89 with forwardly position water trap devices 91 and 92 disposed on opposite sides of the watercraft at equal distances to the longitudinal center line thereof so as to maintain side-to-side balance. The water trap devices 91 and 92 may form one or more internal expansion chambers and baffling arrangements so that the water from the engine cooling system will not flow back through the exhaust system to the engine 23 but will be discharged to the atmosphere along with exhaust gases as now will be described.

Each water trap 91 and 92 discharges water though a respective exhaust pipe 93 and 94 that extend along the length of the watercraft and which pass above the respective cylinder head 64 and 65 so as to maintain a relatively compact construction and permit the free flow of the exhaust

gasses. The exhaust pipes 93 and 94 terminate in oppositely facing discharge openings within the tunnel 31 as seen in FIG. 2. Hence, the exhaust gases will be discharged into the area of the tunnel and may be discharged below the body of water in which the watercraft is operating under some or all speeds for additional silencing. However, the water trap devices 91 and 92 will insure that none of this cooling water can flow back to the engine through the exhaust system, as already described.

A watercraft constructed in accordance with another embodiment of the invention is illustrated in FIGS. 5–9 and is indicated generally by the reference numeral 101. In many regards, the components of this embodiment are the same as those of the embodiment previously described, although the orientation may be slightly different. Where that is the case, the components are identified by the same reference numerals and will not be described again, except insofar as is necessary to understand the construction and operation of this embodiment as to describe the different orientation. In addition, certain of these components are illustrated in more detail in this embodiment and where that is the case, this more detailed construction will be described.

In FIG. 7, the arrangement for mounting the engine 23 in the hull portion 13 is specifically illustrated. This includes a pair of engine mounts 102 that are affixed to the crankcase 38 and which cooperate with elastic isolators 103 and hull mount brackets 104 for mounting the engine 23 resiliently on the hull portion 13. The engine mount 102 and hull mounted brackets 103 are bonded to each other and to the elastic elements 103 in a manner well known in this art.

The layout of the exhaust system of the engine 23 in this embodiment is different from that previously described and for that reason the entire exhaust system will be described. This includes, like the embodiment of FIGS. 1–4, exhaust manifolds 84 and 85 that are affixed to the outboard sides of the cylinder blocks 42 and 43. Unlike the previously described embodiment wherein the expansion chamber devices are positioned also on the outboard side of the engine, in this embodiment, a connecting pipe, indicated by the reference numeral 105 is disposed at each side of the engine and communicates with a forwardly opening discharge port of the respective exhaust manifold 84 and 85. It will be seen that the connecting pipe 105 is of a double wall construction having an outer wall 106 that is spaced from the inner wall 107 and defines therebetween a water jacket 108 that receives coolant from the engine cooling jacket in any suitable manner. The connecting pipe 105 merges into an expansion chamber device 109 which is disposed above the cylinder head 64 and 65 of each of the cylinder banks 42 and 43. This expansion chamber device also has a double wall construction defining a cooling jacket 111 there around. The expansion chamber device 109 passes back over the top of the engine 23 and terminates in a discharge nipple 112 into which the water from the cooling jackets 108 and 111 is dumped for mixing with the exhaust gases.

The expansion chamber nipples 112 communicate with respective exhaust pipes 113 (FIG. 5 and 6) that extend along the sides of the hull outwardly of the tunnel 28 and which terminate in water trap devices 114, each disposed on opposite sides of the tunnel 28. The water trap devices 114 are, therefore, balanced side by side and thus the watercraft 101 is well balanced both in a fore and aft and in a side to side direction. The water trap devices 114 operate like those of the previously described embodiment so as to permit the discharge of water from the engine cooling jacket along with the exhaust gases while precluding any water from flowing into the engine through its exhaust system.

Each water trap device **114** discharges into a respective exhaust pipe **115** which, like the previously described embodiment, discharges into the tunnel **28** for a discharge of the exhaust gases to the atmosphere.

It should be readily apparent from the foregoing description that the described embodiments of the invention provide a very compact engine and watercraft and also an engine that incorporates a transmission so that the engine can operate at a greater speed than the jet propulsion unit which it drives and avoid the likelihood of cavitation. Of course, the foregoing description is that of preferred embodiments of the invention and various changes and modifications may be made without departing from the spirit and scope of the invention, as defined by the appended claims.

We claim:

1. A watercraft comprised of a hull defining an engine compartment, a two-cycle, crankcase compression internal combustion engine contained within said engine compartment and for a watercraft room having a crankcase chamber journaling an output shaft, a pair of cylinder blocks extending at a V-angle to each other and affixed to said crankcase chamber, each cylinder block having at least one cylinder bore containing a piston for driving said output shaft, said cylinder bores having axes lying in a plane that extends transversely to said output shaft, an induction system for said engine disposed substantially completely in a valley defined between said cylinder blocks for delivering at least an air charge to said crankcase chamber for transfer to combustion chambers formed above said pistons, and a pair of exhaust manifolds each affixed to a respective one of said cylinder blocks on the side thereof facing away from said valley.

2. A watercraft as in claim 1, further including an exhaust system for discharging exhaust gases from the exhaust manifolds to the atmosphere including portions extending over the engine.

3. A watercraft as in claim 2, wherein the exhaust system includes water trap means for precluding water from entering the engine through the exhaust system.

4. A watercraft as in claim 3, wherein the water trap means comprises a pair of water traps, each disposed in front of the respective cylinder block.

5. A watercraft as in claim 3, wherein the water trap means comprises a pair of water traps, each disposed to the rear of the engine on the side of the respective cylinder block.

6. A watercraft as in claim 1, further including a pair of expansion chambers, each communicating with a respective one of the exhaust manifolds.

7. A watercraft as in claim 6, wherein the expansion chambers are disposed on the same side of the cylinder blocks as the exhaust manifold.

8. A watercraft as in claim 7, further including an exhaust system for discharging exhaust gases from the expansion chambers to the atmosphere including portions extending over the engine.

9. A watercraft as in claim 6, wherein the expansion chambers are disposed above the respective cylinder banks.

10. A watercraft as in claim 9, further including a pair of water trap devices disposed to the rear of the engine and each communicating with a respective one of the expansion chambers.

11. A watercraft as in claim 10, wherein the exhaust manifolds have discharge ends disposed at the front of the engine and wherein the exhaust manifolds communicate with the expansion chambers by means of connecting pipes that extend substantially vertically upwardly at the front of the engine.

12. A watercraft as in claim 1, wherein each cylinder block has at least two longitudinally spaced cylinder bores

and two pistons, each cylinder bore axis of one cylinder block being in a common transversely extending plane with a corresponding cylinder bore axis of the other cylinder block.

13. A watercraft as in claim **12**, wherein the pistons of each cylinder block drive a respective crankshaft.

14. A watercraft as in claim **13**, wherein the crankshafts drive the engine output shaft through a transmission.

15. A watercraft as in claim **14**, wherein the transmission comprises first and second gears affixed respectively to the crankshafts and each enmeshed with a third gear affixed to the output shaft.

16. A watercraft as in claim **15**, wherein the output shaft is connected to the propulsion device by means of a flexible coupling disposed to the rear of the transmission.

17. A watercraft as in claim **16**, further including a magneto generator driven by one of the crankshafts at one end thereof.

18. A watercraft as in claim **17**, wherein the magneto generator is driven at end of the engine opposite from the transmission.

19. A watercraft as in claim **1**, wherein the propulsion unit is disposed to the rear of the engine.

20. A watercraft as in claim **19**, wherein the propulsion unit comprises a jet pump.

21. A watercraft as in claim **20**, wherein the hull has an opening disposed above the induction system and a removable hatch closing the opening.

22. A watercraft as in claim **21**, wherein the removable hatch closes an opening formed in a further hatch pivotally connected to the deck and having a substantially larger opening.

23. A watercraft as in claim **22**, wherein the first hatch is pivotally carried by the second hatch.

24. A watercraft comprised of a hull defining an engine compartment, a two-cycle, crankcase compression internal combustion engine contained within said engine compartment and having a crankcase chamber journaling an output

shaft, a pair of cylinder blocks extending at a V-angle to each other and affixed to said crankcase chamber, each cylinder block having at least one cylinder bore and containing a piston for driving said output shaft, said cylinder bores having axes lying on a plane that extends transversely to said output shaft, an induction system for said engine disposed substantially completely in a valley defined between said cylinder blocks for delivering at least an air charge to said crankcase chamber for transfer to combustion chambers formed above said pistons, and a pair of exhaust manifolds each affixed to a respective one of said cylinder blocks on the side thereof facing away from said valley, a pair of expansion chambers each positioned on a respective side of said engine and receiving exhaust gases from the respective exhaust manifold, and an exhaust system for discharging the exhaust gasses from said expansion chambers to the atmosphere comprising an exhaust pipe extending from each of said expansion chambers across the top of the engine to the rear of said engine.

25. A two-cycle, crankcase compression internal combustion engine having a crankcase chamber journaling a pair of crankshafts, a pair of cylinder blocks extending a V-angle to each other and each affixed to said crankcase chamber, each cylinder block defining at least one cylinder bore containing one piston for driving the respective crankshaft, an output shaft journaled inside said crankcase between said crankshafts and at a level below the level of said crankshafts, first and second gears affixed respectively to said crankshafts and each enmeshed with a third gear affixed to said output shaft for driving said output shaft from said crankshafts, and a magneto generator driven by one of said crankshafts at one end thereof.

26. An engine as in claim **25**, wherein the magneto generator is driven from the end of the engine opposite from the transmission.

27. A watercraft comprised of a hull defining an engine compartment, an engine contained within the engine compartment, and an exhaust system extending from the engine to an exhaust discharge, the engine including an engine body journaling an output shaft to rotate about a rotational axis, the engine body having at least one cylinder which defines a cylinder axis and which contains a piston connected to the output shaft, the engine body including at least one intake port provided on a first side of a plane which contains the cylinder axis and the rotational axis of the output shaft, and at least one exhaust port provided on a second side of the plane, opposite the first side, the exhaust system including an expansion chamber having upstream and downstream ends and having a diverging portion at the upstream end, at least a portion of the expansion chamber being positioned on the first side of the plane.

28. The watercraft according to Claim 27 additionally comprising an exhaust manifold mounted to the engine body on the second side of the plane so as to communicate with the at least one exhaust port.

29. The watercraft according to Claim 28 additionally comprising a forward facing outlet provided on the exhaust manifold, and an exhaust passage extending from the outlet of the exhaust manifold, around a forward end of the engine body and to the expansion chamber.

30. The watercraft according to Claim 28 additionally comprising an outlet provided on the exhaust manifold and positioned at a forward end of the engine, an exhaust passage connecting the outlet with the expansion chamber, and a first water jacket in thermal communication with the exhaust passage.

31. The watercraft to according to Claim 30 additionally comprising a second water jacket in thermal communication with the expansion chamber, the first and second water jackets being in fluidic communication with each other.

32. The watercraft according to Claim 31 additionally comprising a third water jacket in thermal communication with the exhaust manifold, the third water jacket being in fluidic communication with the first water jacket.

33. The watercraft according to Claim 31 additionally comprising a third water jacket in thermal communication with the engine body, the third water jacket being in fluidic communication with the first water jacket.

34. The watercraft according to Claim 31 additionally comprising a water jacket discharge provided downstream from the expansion chamber, the water jacket discharge

configured to discharge water from the second water jacket into exhaust gases which flow through the exhaust system.

35. The watercraft according to Claim 34, wherein the water jacket discharge is provided at an elevation below the downstream end of the expansion chamber.

36. The watercraft according to Claim 27 additionally comprising an intake manifold mounted to the engine body on the first side of the plane so as to communicate with the least one induction port, the expansion chamber being arranged above the induction port.

37. The watercraft according to Claim 27, wherein the cylinder axis is inclined with respect to a vertical plane.

38. The watercraft according to Claim 37, wherein the at least one cylinder is provided in a first cylinder block and the engine further comprises a second cylinder block arranged in a V-type configuration with respect to the first cylinder block.

39. The watercraft according to Claim 27, wherein the entire expansion chamber is positioned on the first side of the plane.

40. The watercraft according to Claim 27 additionally comprising a watertrap communicating with the expansion chamber and positioned downstream from the expansion chamber.

41. The watercraft according to Claim 40, wherein the watertrap is positioned on the second side of the plane.

42. The watercraft according to Claim 40, wherein the expansion chamber is provided at an elevation above the watertrap.

43. The watercraft according to Claim 27, wherein the expansion chamber is inclined with respect to a horizontal plane such that the upstream end is higher than the downstream end.

44. The watercraft according to Claim 27 additionally comprising a hull tunnel formed on a lower surface of the hull and having a side wall, the exhaust discharge configured to discharge exhaust gases through the side wall of the hull tunnel.

45. The watercraft according to Claim 27, wherein the expansion chamber is positioned above the engine body.

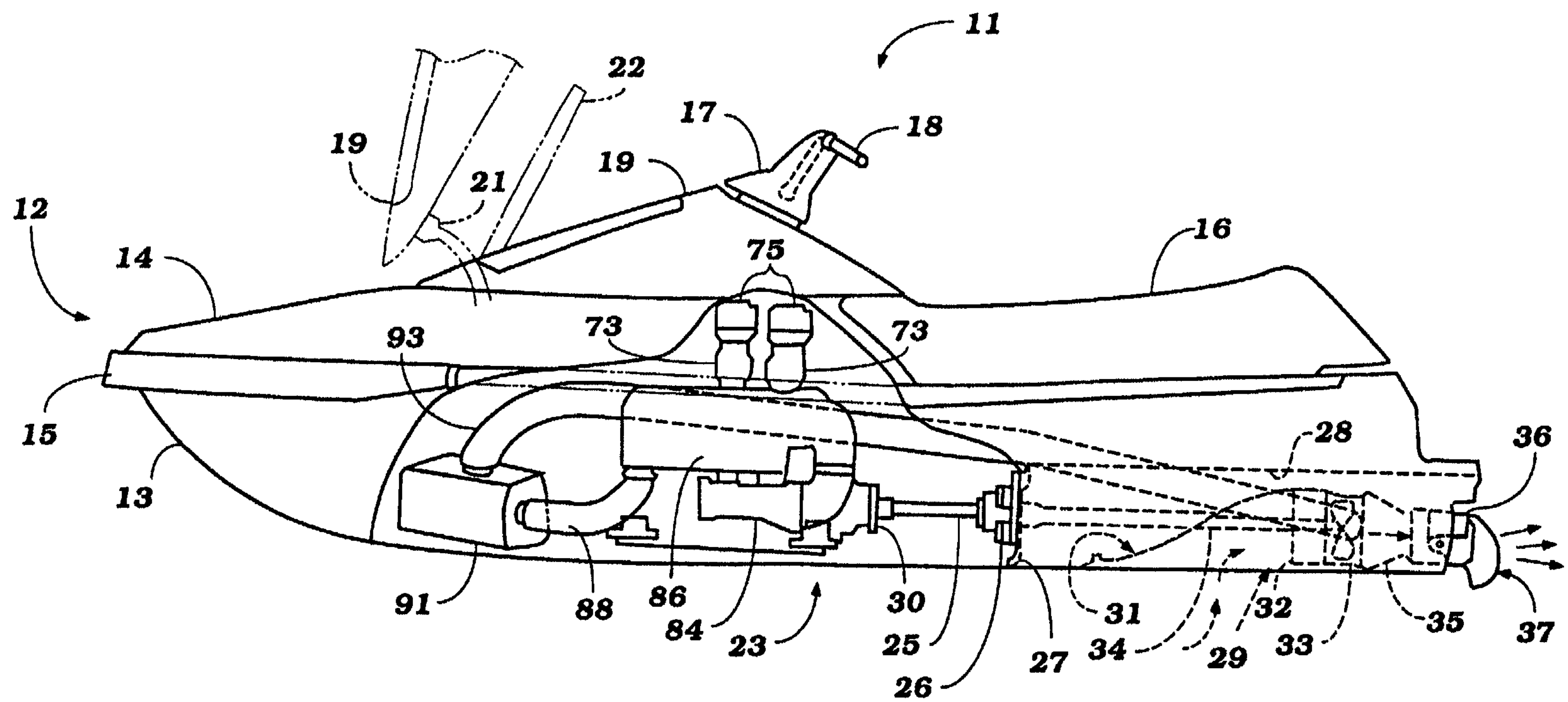
46. The watercraft according to Claim 27, wherein the engine is a two-cycle, crankcase compression internal combustion engine.

47. The watercraft according to Claim 27, wherein the expansion chamber includes a converging portion at the downstream end.

[57] **ABSTRACT**

Two embodiments of two-cycle V-type crankcase compression internal combustion engines for powering a jet propelled watercraft. In each embodiment, the pistons of the cylinder banks each drive their own crankshafts which are geared by a transmission to an output shaft. The exhaust system for the engine is disposed on the outside of the cylinder banks and includes an expansion chamber and a portion of the exhaust system that passes over the engine. The induction system for the engine is positioned in the valley between the cylinder banks.

Figure 1


11
12
13
14
15
16
17
18
19
19
21
22
23
25
26
27
28
29
30
31
32
33
34
35
36
37
73
73
75
84
86
88
91
93

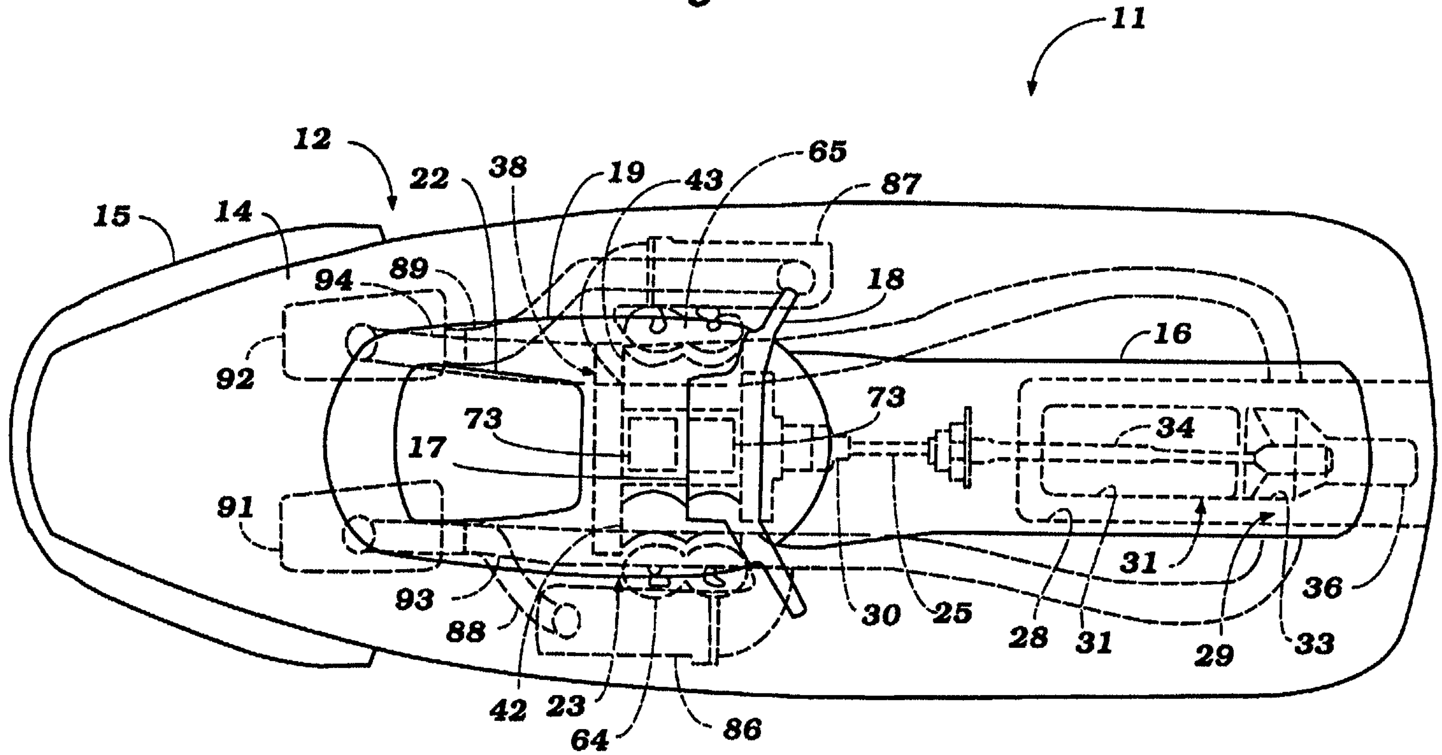

11
12
22
38
19
43
65
87
15
14
94
89
18
16
92
73
34
17
91
31
36
93
88
30
25
28
29
33
42
23
64
86

Figure 2

Figure 3

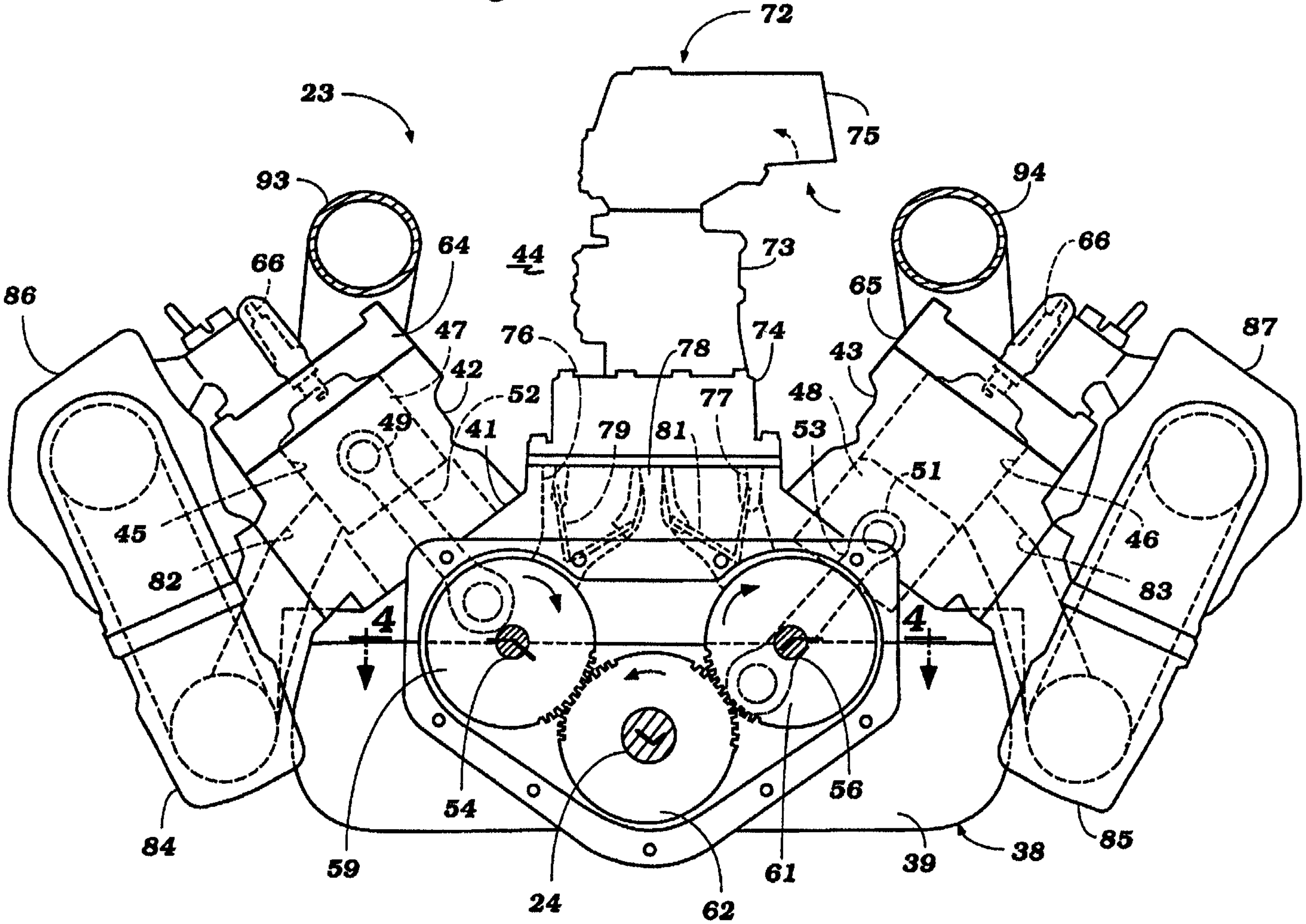

72
23
75
93
94
64
66
44
73
65
66
86
47
76
74
78
43
87
42
52
48
77
49
41
79
81
53
51
45
46
82
83
4
4
84
54
56
85
59
24
61
39
38
62

Figure 4

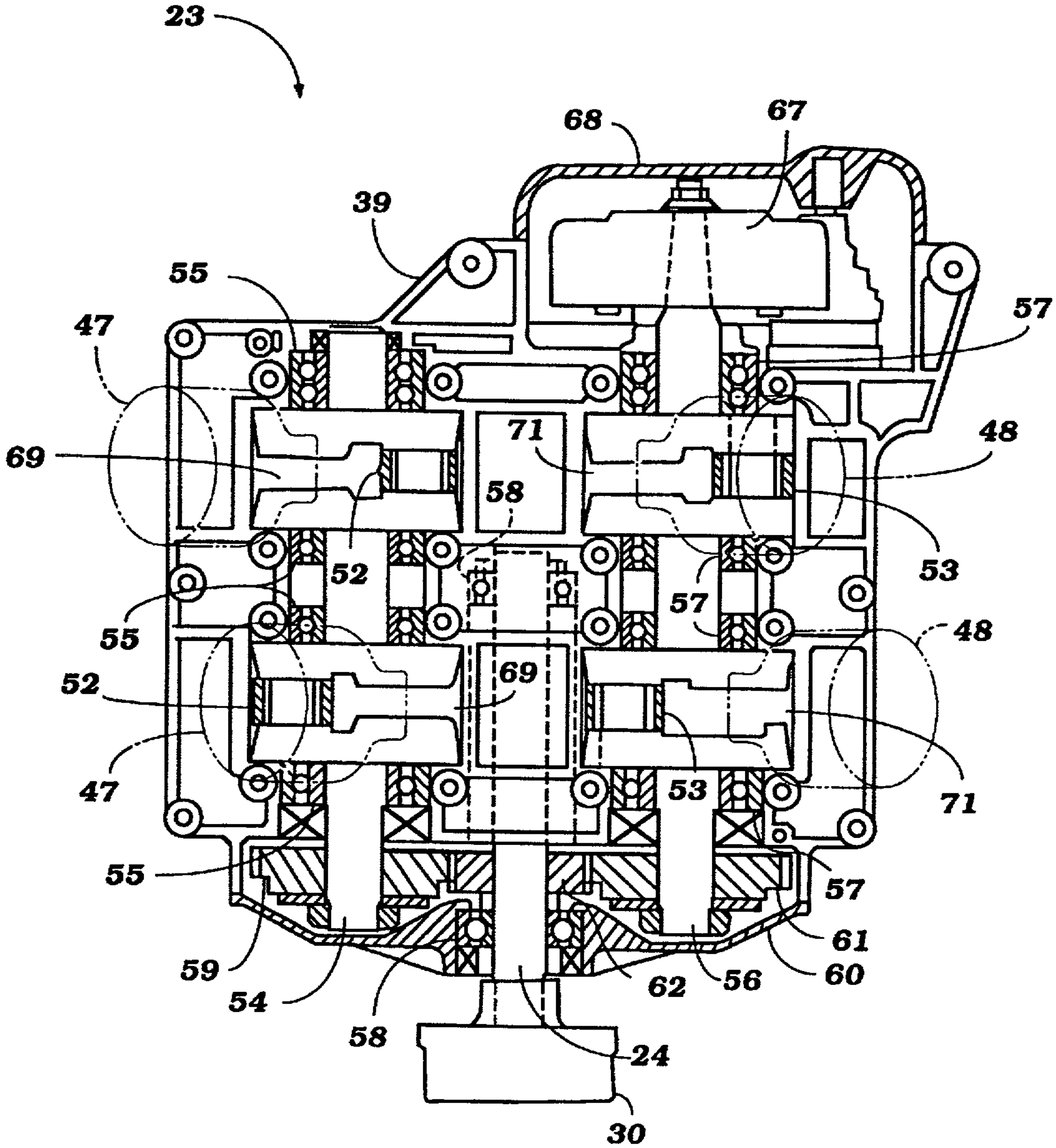
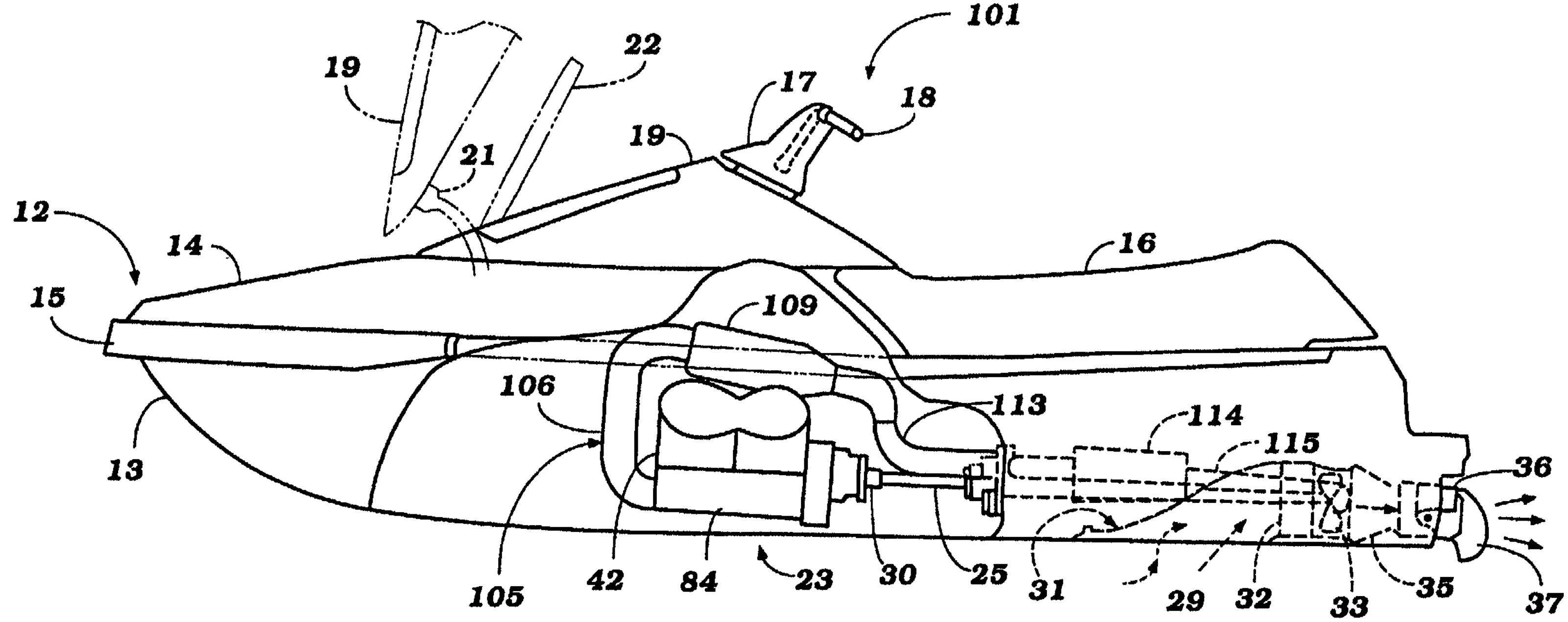
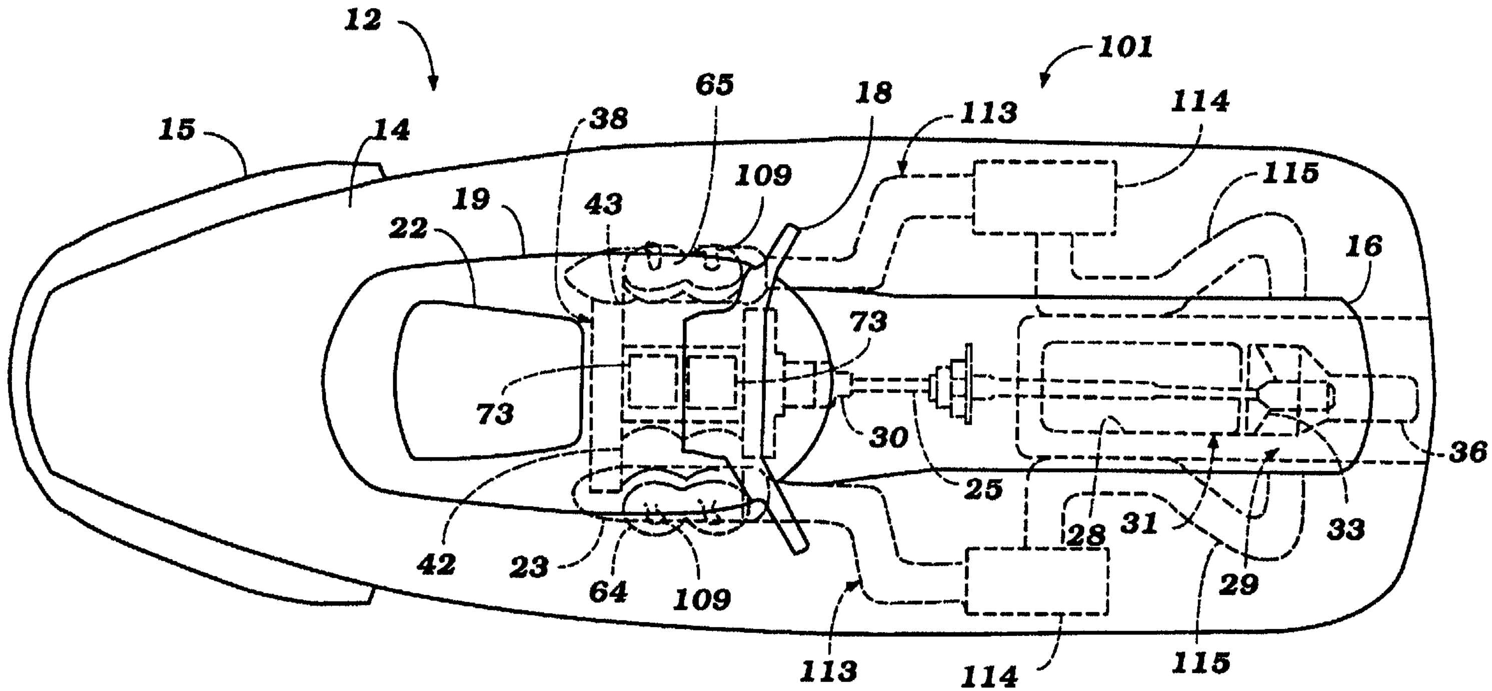

23
68
67
39
55
57
47
71
48
69
58
52
53
55
57
48
52
69
47
53
71
55
57
61
59
54
58
62
56
60
24
30

Figure 5



101
19
22
17
18
21
19
12
14
16
15
109
106
113
114
115
13
36
105
42
84
23
30
25
31
29
32
33
35
37

Figure 6


12
101
15
14
38
65
18
113
114
115
19
43
109
22
16
73
73
30
36
25
28
31
33
42
23
64
109
29
113
114
115

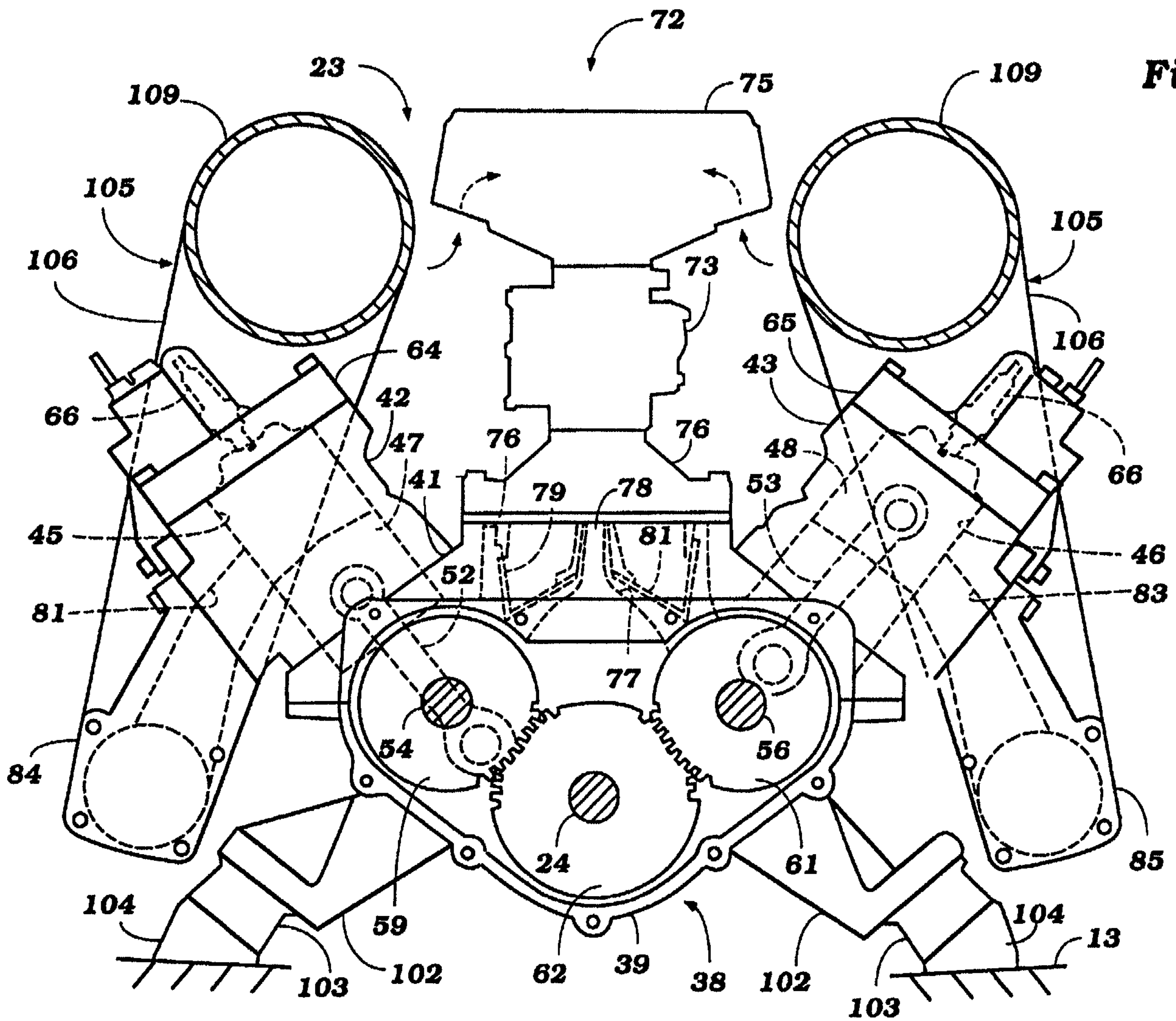

72
23
75
109
109
105
105
106
106
73
64
65
43
42
47
66
66
76
76
48
41
79
78
53
81
45
46
52
83
81
77
54
56
84
24
61
85
59
104
104
13
102
62
39
38
102
103
103

Figure 7

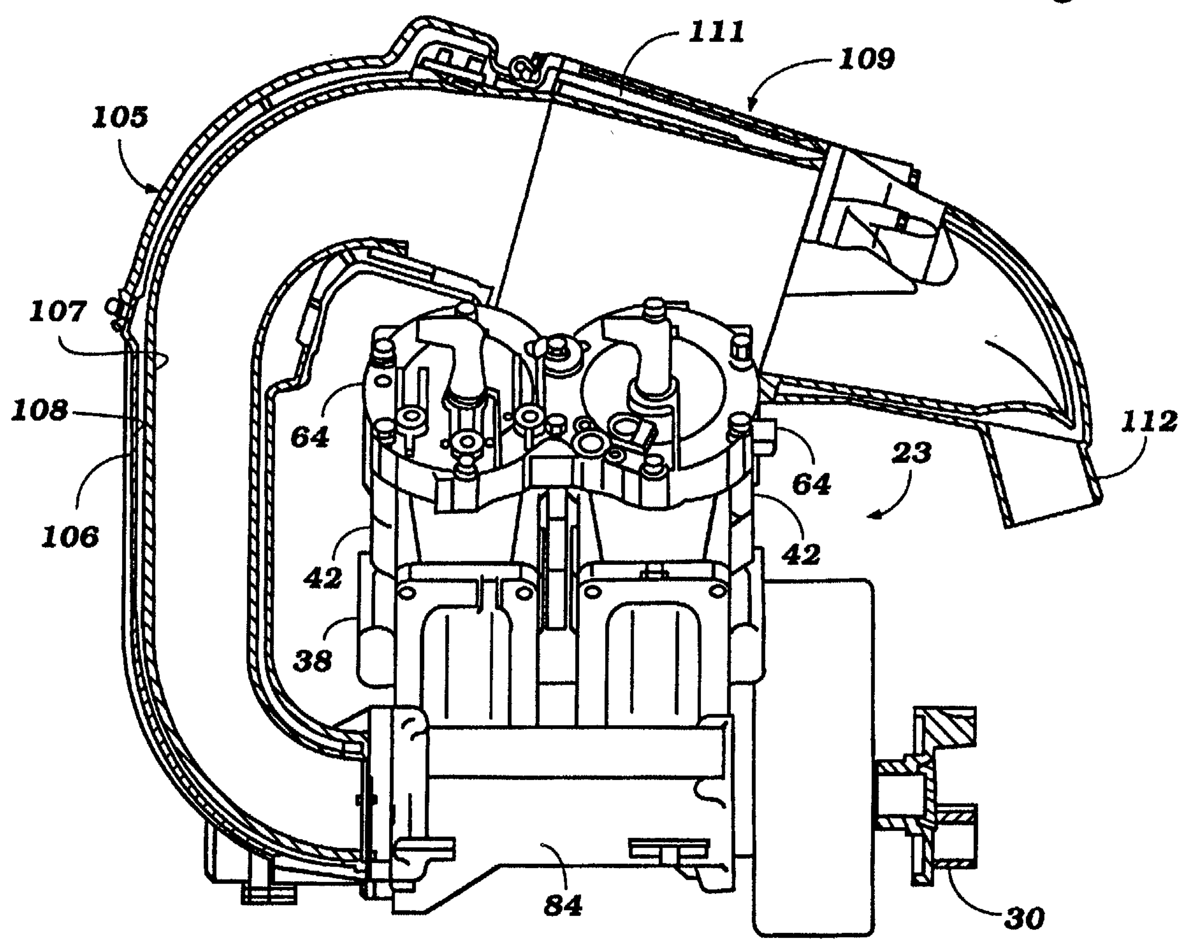


Figure 8

Figure 9